PHOTOTHERMAL INSPECTION OF IMPACT DAMAGES ON CARBON-GLASS FIBRE COMPOSITES USING A SIMPLE HAND SCANNER MEASUREMENT SYSTEM

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INTRODUCTION

Composite plates having durable and lightweight structure are most interesting materials considering several applications. Because durability is a major criteria, it is important to develop methods for finding flaws that affect this quality. In the case of carbon-glass fibre composites we have earlier demonstrated the suitability of radio frequency (RF) induction heating combined with IR-detection [1]. Based on the good experiences obtained with the method, a suitable equipment for field experiments was developed. Last year we showed the feasibility of a transportable thermal NDT equipment using laser line heating [2]. Modifying this measurement system for RF induction heating, several disadvantages of laser heating can be overcome.

In order to test the ability of the system to find flaws in carbon-glass fibre composites, artificial damages simulating impact damages were made to a composite plate. The plate was then inspected using RF induction heating and hand held scanner.

MEASUREMENT SYSTEM

The equipment used for inspecting carbon-glass fibre plates (Fig. 1.) is divided into a scanner unit and a remote control unit. An operator holds the scanner unit in his hand and moves around the inspected object while the remote unit is placed out of the operator's way.

The scanner unit contains a RF induction coil for line heating and a infrared line scanner for monitoring the surface temperature of the composite plate. The size of the heating coil is 60 mm in length and 7 mm in width. The line scanner consists of a LN_2-cooled HgCdTe detector, a Ge lens, and a deflection mirror. The scanner samples the temperature field in a horizontal line parallel to the heating coil. The whole scanner unit is moved manually over the composite plate in the vertical direction and thus the wanted surface area can be heated and inspected simultaneously.

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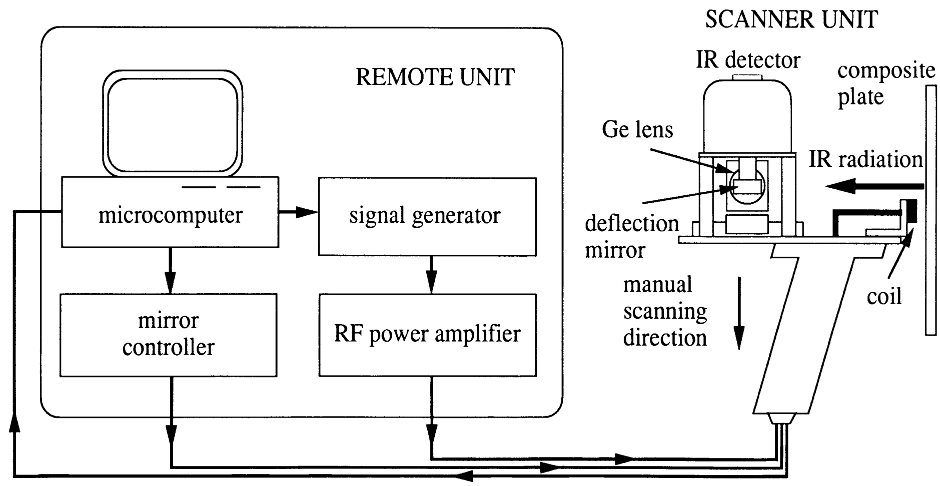

Fig. 1. A schematic drawing of the measurement system.

The control electronics needed, a RF power amplifier and a microcomputer are placed in the remote unit. The computer controls the heating and the sampling rate of the IR line scanner via a multifunction data acquisition board. It also collects, stores, and handles the data obtained with the scanner. The data is normally presented in the form of a pseudo-color image on the computer monitor. The RF power amplifier operates in the frequency region of 1 MHz to 30 MHz having a maximum output capability of 200 W.

Although constructing a coil with a suitable resonance frequency and a high power transfer capability at the same time may be somewhat complicated, several advantages compared to laser heating are achieved. Mechanically the heating coil is very rugged and suitable for harsh conditions, whereas the focusing optics and the laser are necessarily not. With RF induction there is no special cooling requirements and the equipment takes less space. Lastly, the price of RF power amplifier is considerably less than that of high power laser.

EXAMPLES OF RESULTS

With RF induction selective heating can be obtained. When having a composite sample consisting of both conductive and dielectric materials, the RF method heats up only the conductive elements. Although the spatial resolution of the resulting images may not be as good as with using, say, laser heating, the images have higher contrast due to the selective heating. In the case of carbon-glass fibre composites the carbon fibre is a conductor, while the glass fibre is a dielectric. Thus the effect of selective heating can be utilized.

The inspected composite plate consists of several carbon fibre nets on top of each other with glass fibre between them. On this plate artificial damages simulating impact damages were made using Brinell and Vickers indentors (loads 500 kg and 187.5 kg respectively). Surrounding each defect an area of 6 cm x 3 cm was inspected. Measurement time for each of the areas was about 6 seconds. Figs. 2b and 3b present two of these defects schematically with respect to the carbon fibre nets shown black and dark gray.

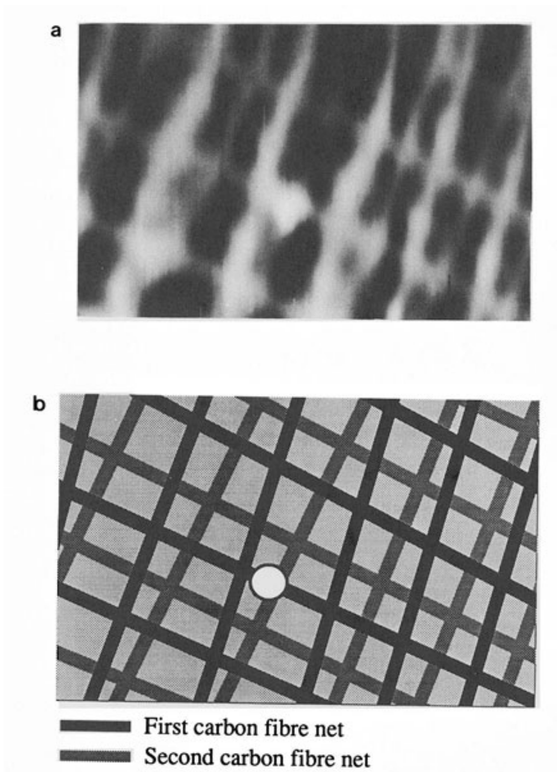

Fig. 2. a) Thermal image of an artificial defect made with Brinell indentor (load 187.5 kg) on a carbon-glass fibre composite. b) The defect shown schematically in respect to the carbon fibre nets.

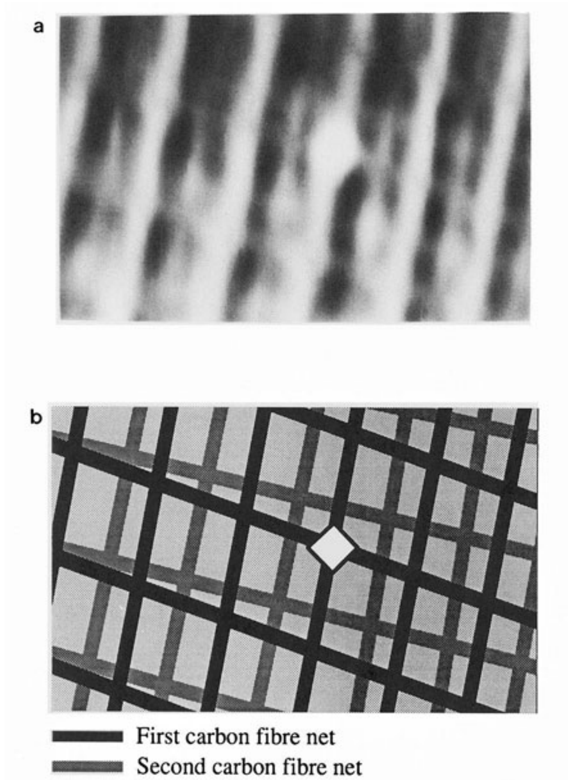

Fig. 3. a) Thermal image of an artificial defect made with Vickers indentor (load 187.5 kg) on a carbon-glass fibre composite. b) The defect shown schematically in respect to the carbon fibre nets.

In Fig. 2a a thermal image of the defect made with Brinell indentor is shown. The color table is selected so that the hotter areas show as white. The defect can clearly be resolved as a hot area in the middle of the image. The size of the defect area is about 5 mm x 5 mm. The heating coil moves in the image from left to right. The carbon fibres parallel to the coil heat up more strongly and thus they are better resolved. Although only a very thin surface layer is heated due to the high resonance frequency, the second carbon fibre net can be seen under the first one. Fig. 3a shows a similar thermal image of a Vickers indentation. As in the case of Brinell indentor the defect is clearly visible also here. Both figures represent raw data without any image enhancement. It should also be noticed that the inspected areas are sweeped manually and frame averaging cannot be used.

CONCLUSIONS

We have demostrated a simple photothermal hand scanner equipment using radio frequency induction for heating. The equipment is especially developed to be used in harsh working conditions and it can be transported to almost any place where non-destructive testing needs to be done. In addition, the equipment is easy to use and the price is reasonable considering industrial applications. In the examples presented here, the artificial defects made on a carbon-glass fibre composite plate were detected without difficulties.

REFERENCES

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